

**NASA Ames Simulation Laboratories
Year in Review
FY 2003**

Acknowledgements

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This document was produced by Kathleen Starmer, Northrop Grumman Information Technology.

About the cover...

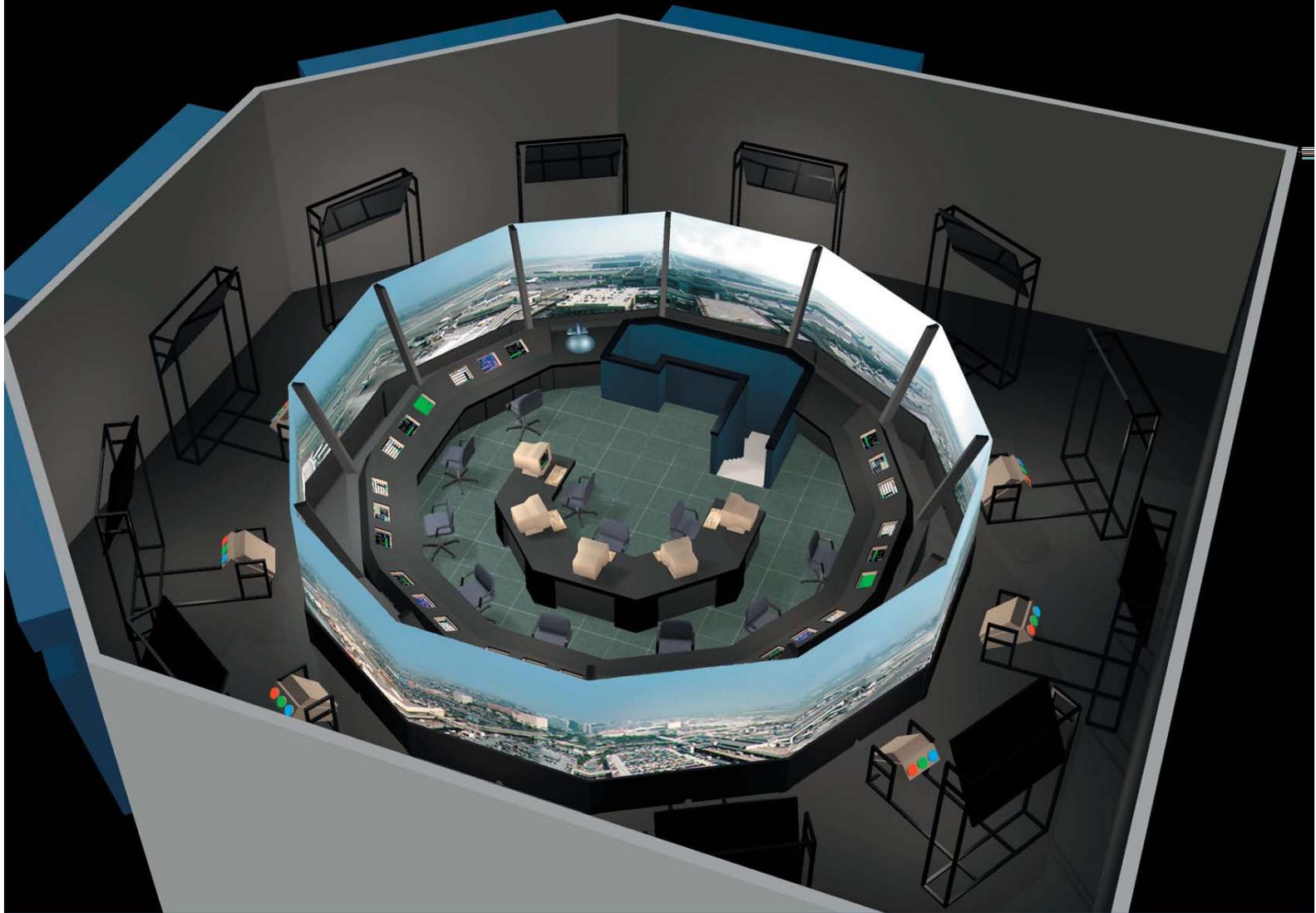
Simulations from each of the three SimLabs facilities are depicted on this year's cover.

- FutureFlight Central (FFC) has added the Kennedy Space Center (KSC) Shuttle Landing Facility to its library of visual databases, as shown in the top image. Researchers can use FFC to observe a simulated Space Shuttle on approach, landing, and rollout, and to view all post-landing convoy operations. Such simulations may be used to train new ground personnel, keep the skills of existing personnel current, and to simulate emergency response in off-nominal situations. Details about this year's KSC simulation can be found on page 20.
- The Dallas/Fort Worth International Airport Perimeter Taxiway Demonstration, depicted in the center of the cover and conducted at FutureFlight Central and the Crew Vehicle Systems Research Facility, marked the first use of the facilities' newly-developed High Level Architecture (HLA) connectivity in a production simulation. Additional information about this project can be found on page 15.
- The image toward the bottom of the cover shows a model of the Comanche RAH-66 rotorcraft which was used during this year's Comanche Helmet-Mounted Display Symbology Simulation at the Vertical Motion Simulator. This project explored the effectiveness of different helmet-mounted display symbology sets. Details about the study may be found on page 19.

Front and back covers: The three facilities that constitute SimLabs rely on in-house graphics modeling to depict aircraft in each simulator's out-the-window view. On the front cover, we see a model of a Boeing 747; a wireframe version of the same aircraft is shown on the back cover (images courtesy of Dave Carothers, Northrop Grumman Information Technology).

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The FutureFlight Central tower cab provides a spectacular 360-degree field-of-view.

Executive Summary

The staff of the NASA Ames Simulation Laboratories is pleased to present the Annual Report for Fiscal Year 2003. The past year was highly productive, covering a broad range of successful aerospace technology research experiments. Research focused on crucial topics such as aerospace transportation safety, air transportation system capacity, innovative information technology applications, and development of advanced aerospace vehicle concepts.

Three major research and test facilities in the Aviation Systems Division constitute the Simulation Laboratories (SimLabs): the Crew Vehicle Systems Research Facility (CVSRF), FutureFlight Central (FFC), and the Vertical Motion Simulator (VMS). Within the Division, the Aerospace Simulation Operations Branch manages and operates the facilities, with the technical support of Northrop Grumman Information Technology. With this premier suite of facilities and expert staff, Ames has the capability for high fidelity simulation of all elements of aerospace vehicle and transportation systems, including airport ground operations, air traffic management, crew station issues, crew/vehicle interfaces, vehicle design, flight dynamics, and handling qualities. Throughout the year, the SimLabs staff has operated all of the facilities with consistently excellent quality, exemplary safety, and dedication to customer satisfaction. We continue to work with our customers and research partners from government, industry, and academia to find ways to improve SimLabs' operation and efficiency and to meet the challenges of future research and economic trends.

Key Activities in Fiscal Year 2003

SimLabs continued its support of the Space Shuttle Program with simulations of the approach and landing phases of the Orbiter's mission. The astronauts used the facilities for training purposes, as well as for examining numerous potential landing scenarios. Engineering studies were also conducted to examine an upgraded tire load persistence model.

A study of the Comanche helicopter's helmet-mounted display system was also conducted at SimLabs. Several display symbology variations were examined in support of the Comanche's airworthiness evaluations.

SimLabs was involved in research activities in the areas of aerospace transportation safety and capacity, as well. The Extreme Short Take-Off and Landing aircraft simulation, for example, studied potential improvements to traffic flow at airports. An additional study of perimeter taxiways evaluated the benefits of new taxiway designs that alleviate the need for pilots to cross active runways.

Over the past few years, SimLabs has been preparing for real-time, integrated, system-level, distributed simulations. A great example of this new capability is the Virtual Airspace Simulation Technology-Real-Time (VAST-RT) Project. VAST-RT prototyped revolutionary breakthroughs in integrated simulation technology this fiscal year, conducting four interim tests to create a foundation that will ultimately enable a more comprehensive simulation of the National Airspace System.

Looking Ahead to Fiscal Year 2004

SimLabs has partnered with the Lockheed Martin Company to develop and conduct Joint Strike Fighter (JSF) simulations. This work will support the development of the aircraft's Short Take Off/Vertical Landing (STOVL) characteristics. There are some renewed activities in our long-term relationship with the Army rotorcraft research organizations, as well. We anticipate that the Comanche and CH-47 Program Offices will have simulation requirements for the near future.

SimLabs is also working towards long-term involvement with various aspects of the Space Transportation programs. The group is very active in the requirements planning stages of the Orbital Space Plane program, and we are planning simulation requirements in support of NASA's Space Architect activities. Additionally, we expect to be a significant contributor to the Return to Flight efforts which will return the Shuttle fleet to operational status.

An effort that will continue from the past Fiscal Year is the VAST-RT Project, an element of the Virtual Airspace Modeling Systems (VAMS) Project. The Project will conduct another series of interim tests, culminating in a major VAMS Program Milestone at the end of the Fiscal Year: VAST-RT will simulate National Airspace traffic flows, gate-to-gate, in a real-time, human-in-the-loop environment.

What Can be Found in This Annual Report

This year's Report contains brief descriptions of each of the SimLabs facilities and references to sources of more detailed information. Also included is information about the year's simulation research projects, including a special feature on the VAST-RT Project. A list of acronyms used throughout the document is included at the end of the Report.

Tom Alderete and Barry Sullivan, Aviation Systems Division

The Advanced Concepts Flight Simulator can be customized to simulate a variety of aircraft.



Simulation Facilities

Ames' Simulation Facilities are national resources, providing unique, crucial capabilities to the research community. The facilities are connected by a High Level Architecture interface, allowing for distributed simulations. A brief description of each facility follows. More detailed information can be found on our website: www.simlabs.arc.nasa.gov.

FutureFlight Central (FFC) Research Facility

FutureFlight Central is a world-class airport operation simulation facility that has the look and “feel” of an actual Air Traffic Control (ATC) tower. This unique facility offers a “full immersion” virtual airport environment in which planners, managers, controllers, pilots, and airlines can work together in real-time to test software performance, safety, and reliability under realistic conditions. FFC is dedicated to solving present and emerging capacity problems of the nation’s busiest airports and has the capability to support cost-benefit studies of planned airport expansions.

At FFC, it is possible to simulate the most complex airport operations, including real-time peak air traffic control with 12 controller positions, eight ramp tower positions, and 13 pseudo-pilot positions. The controller positions are interchangeable to accommodate any air traffic control tower configuration. FFC’s full-size tower cab is equipped with functional consoles and interactive radar displays. The facility has a modular design that enables information sharing among multiple users with 360-degree views. Highly accurate simulations can be run from the tower under a variety of variable conditions (e.g., weather, time of day, visibility).



The tower cab at FFC.

The simulation facilities at FFC adhere to an open architecture which allows flexibility of operational use and custom configurations. For example, components can be configured to support a variety of subsystems that might exist in some airport facilities but not others. FFC’s open architecture system allows new technologies to be incorpo-

rated during the design phase and life cycle upgrades. The environment at FFC provides a stable platform from which new requirements can be derived, offering pilots and controllers an opportunity to evaluate changes to any airport.

The sophisticated capabilities of FFC allow it to be used as more than just an ATC tower simulator, however. Indeed, FFC can be thought of as a *visualization tool*. For example, FFC possesses a Mars database and could be used as a simulated control center for directing future Mars-based robotic missions. FFC can also be used as an “eye in the sky,” depicting, for instance, space craft operations in the vicinity of the International Space Station. For simulations where it is advantageous to visualize scenarios using a three-dimensional, 360-degree format, FFC is the tool of choice.

Crew Vehicle Systems Research Facility (CVSRF)

The Crew Vehicle Systems Research Facility is a national research resource designed for the study of human factors in aviation safety. The facility is used by researchers to analyze performance characteristics of flight crews, formulate principles and design criteria for future aviation environments, evaluate new and existing air traffic control procedures, and develop new training and simulation techniques required by the continued technical evolution of flight systems. The CVSRF facility supports NASA, the Federal Aviation Administration (FAA), and industry research programs.

Studies have shown that human error plays a part in 60 to 80 percent of all aviation accidents; therefore, continued research to improve safety technologies and procedures is imperative. CVSRF allows scientists to study how errors occur and assess the effects of automation, advanced instrumentation, and factors such as fatigue, on human performance.

The facility includes two flight simulators—a Boeing 747-400 Level D-certified simulator and an Advanced Concepts Flight Simulator (ACFS)—and a simulated Air Traffic Control environment that operates with the Ames-developed Pseudo-Aircraft Systems (PAS) software. Both flight simulators are capable of full-mission simulation and have advanced visual systems that provide out-the-window cues in the cockpit.

Each simulator has a dedicated experimenter's station for monitoring and controlling the simulator. The experimenter's station contains a suite of computer graphic displays, keyboards, and terminals for interacting with the simulation computers, status lights and emergency controls, communication and audio systems, and other useful equipment. In addition to the main experimenter consoles, each of the simulators has an observer station on board from which experimenters can communicate with the simulator crew or observers.



Pilots flying a test run in the Boeing 747 simulator.

Boeing 747-400 Simulator

The Boeing 747-400 Level D simulator represents the cockpit of one of today's most sophisticated airplanes. It is equipped with programmable flight displays that can be easily modified to enhance the flight crew's situational awareness and thus improve systems safety. In addition, the simulator offers a digital control loading system, a six-degree-of-freedom motion system, a digital sound and aural cues system, and a fully integrated autoflight system that provides aircraft guidance and control. It is also equipped with a weather radar system.

The 747-400 simulator provides all modes of airplane operation, from cockpit preflight to parking and shutdown at the destination. The simulator's crew compartment is a fully detailed replica of a current airline cockpit, and all instruments, controls, and switches operate in the same way as they do in an actual aircraft. To ensure simulator fidelity, the 747-400 is maintained to the highest possible level of certification established by the FAA for airplane simulators, which ensures credibility of results for research conducted in the simulator.

Advanced Concepts Flight Simulator (ACFS)

This unique research tool simulates a generic commercial transport aircraft and employs many advanced flight systems representative of the newest aircraft being built today. The ACFS generic aircraft was conceived and sized on the basis of projected usage needs in the 21st Century. Among its many advanced systems, the ACFS includes touch-sensitive electronic checklists, cutting edge graphical flight displays, aircraft systems schematics, and a flight management system. The ACFS is mounted atop a six-degree-of-freedom motion system and uses side-stick controllers for aircraft control in the pitch and roll axes.

The ACFS' visual generation and presentation systems closely match those of the 747-400 simulator, and the visual scenes can depict specific airports and their surroundings as viewed from the cockpit at day, twilight, or night. Currently, the ACFS is used to simulate a generic 757-size aircraft and a C-17 transport vehicle. However, the system's built-in flexibility allows it to be configured to simulate a wide range of other flight vehicles in the future, including new aerospace prototypes.

Air Traffic Control (ATC) Simulator

The Air Traffic Control environment is a significant contributor to pilot workload and, therefore, to the performance of crews in flight. Full-mission simulation is greatly affected by the realism with which the ATC environment is modeled. From the crew's standpoint, this environment consists of dynamically changing verbal or data-link messages, some addressed to or generated by other aircraft flying in the immediate vicinity.

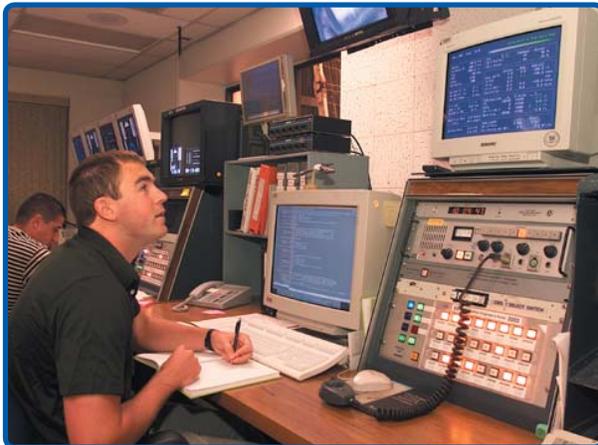
CVSRF's ATC simulator is capable of operating in three modes: stand-alone, without participation by the rest of the facility; single-cab mode, with either the ACFS or the 747-400 participating in the study; and dual-cab mode, with both cabs participating.



CVSRF's ATC simulator can operate independently or linked with the flight simulators.

Vertical Motion Simulator (VMS) Complex

The VMS complex is an important national resource that supports many of the country's most sophisticated aerospace Research and Development programs. The VMS offers three laboratories capable of supporting such research: the motion lab and two fixed-base labs. This dynamic and flexible research environment lends itself readily to simulation studies involving controls, guidance, displays, automation, handling qualities, flight deck systems, accident investigations, and training. Other areas of research include the development of new techniques, technologies, and methodologies for simulation and the definition of requirements for other training and research simulators.



Simulation engineers at the VMS ensure that researchers' projects run smoothly.

Housed in a ten-story tower, the VMS motion base is the largest in the world, allowing the VMS to provide the highest level of motion fidelity available in the simulation community. The large amplitude motion system allows the simulator to travel up to 60 feet vertically and 40 feet laterally. The simulator operates with three translational degrees of freedom (vertical, lateral, and longitudinal) and three rotational degrees of freedom (pitch, roll, and yaw), and it can perform at maximum capability in all axes simultaneously.

The operational efficiency of the laboratory is enhanced by the Interchangeable Cab (ICAB) system, which consists of five different interchangeable and completely customizable cabs. The flexibility of the ICAB system allows the VMS to simulate any type of vehicle, whether it is already in existence or merely in the conceptual phase. Each ICAB is customized, configured, and tested at a fixed-base development station, after which it is either used in-place for a simulation at one of the VMS's fixed-base labs or moved onto the motion platform.

Digital image generators in the laboratory provide full-color scenes on six channels, multiple eye points, and include a chase plane point-of-view. The VMS labs maintain a large inventory of customizable visual scenes with a unique in-house capability to design, develop, and modify the inventory of its databases. Real-time aircraft status information can be displayed to both pilot and researcher through a wide variety of analog instruments and head-up, head-down, or helmet-mounted displays.

Virtual Laboratory (VLAB) is a software tool within the VMS complex that provides a new approach to aerospace research and development. The software is flexible, portable, and capable of operating on a variety of platforms including PC, Macintosh, and SGI. VLAB presents a virtual replica of the VMS lab environment in which a remote user can interactively define specific data and display configurations that will afford the most productivity. By housing VLAB on the remote researcher's computer and only shuttling *data* between facilities, VLAB allows researchers at distant locales to participate in VMS simulations in real-time. Currently, VLAB is used for all VMS Space Shuttle simulations, and researchers at Johnson Space Center are able to participate without leaving their home base. The VLAB concept, however, has a much broader potential, offering researchers the ability to monitor and actively participate in simulations using wind tunnels, flight test facilities, and interoperable labs from any location within the U.S. by remote access.



VLAB allows remote researchers to participate in VMS simulations in real-time. This shows a typical VLAB display.

The Vertical Motion Simulator's completely customizable interchangeable cabs allow virtually any vehicle to be simulated at the facility.



Research at SimLabs

Extreme Short Take-Off and Landing Aircraft Simulation

Principal Investigator: Robert K. Callaway, NASA Ames Research Center

Summary

This simulation investigated the operational potential of an Extreme Short Take-Off and Landing (ESTOL) aircraft to improve air traffic at a regional or major hub airport. A video of the simulation was produced to demonstrate ESTOL's operational benefits to the future of the wider aviation community.

Introduction

Dallas/Forth Worth International Airport (DFW) is one of the largest and busiest airports in the United States and typically experiences many delays as a result of backed up arriving and departing air traffic. Consequently, new concepts are being explored to help maximize airspace and runway potential for both this airport and other airports across the country.

Commercial runways average between 8,000 to 12,000 feet in length. Researchers from NASA's Aeronautical Projects and Program Office, along with the Aircraft Design Lab at Cal Poly (San Luis Obispo), have created a conceptual model of an ESTOL aircraft that could use runways shorter than 3,000 feet. A key aspect of the ESTOL design would allow Simultaneous Non-Interfering (SNI) approaches that could enhance operational throughput capacity. In contrast to conventional jets, SNI operations would generate less noise in the runway proximity and use tight, simultaneous descending, decelerating, curved approaches and ascending, accelerating, curved departures.

An ESTOL aircraft, operating with an SNI profile, could utilize facilities with short runways, such as hub cargo areas or regional airports. By allocating some operations to smaller runways, ESTOL vehicles could significantly reduce congestion at hub airports such as DFW and provide greater flexibility and efficiency to the National Airspace System. Across the United States, there are numerous short runways; in California alone, there exist at least 50 runways that could be used without modification for ESTOL operations.

SimLabs' FutureFlight Central (FFC) facility provides an excellent forum for simulating ESTOL takeoffs and landings. In October 2002, an experiment was conducted at FFC to demonstrate ESTOL routing and air traffic patterns within an airport exclusion zone at DFW. The goal was to conceptualize the operational requirements at airport hubs using SNI approaches and reduce perceived noise.

Simulation

The DFW east-side model included three parallel runways, one diagonal runway, and realistic air traffic operations. FFC's simulation engineers dynamically simulated the ESTOL aircraft, modeling approaches and departures within the hub and demonstrating ESTOL's operational possibilities for the future. Flight parameters used for this simulation included: rate-of-turn/climb/descent, cruise speed, final approach speed, descent speed, and landing speed. Daylight conditions and south traffic flows were modeled, with the ESTOL aircraft landing on Runways 13L and 31R.

Results

FFC's simulated air traffic operations and superior visual capabilities helped researchers conceive of how an ESTOL aircraft could operate within the environment of a major hub airport. The ability to change viewpoints was also essential in visualizing the operational possibilities from the air and the ground. Results of this simulation helped researchers identify the need for a software tool that will optimize the tradeoffs between vehicle type, operations, and economic impact to the air traffic system.

Using digital footage of the simulation, a short video was developed to demonstrate ESTOL's operational benefits to the future of the wider aviation community. The video was shown as part of a keynote presentation at the November 2002 International Powered-Lift Conference.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology



The ESTOL aircraft as it appeared in FFC during the simulation.

Space Shuttle Vehicle – 2003

Principal Investigator: Ron Garan, Astronaut Office

Summary

Simulations of the Space Shuttle Vehicle (SSV) were conducted at the Vertical Motion Simulator (VMS) complex to provide landing and rollout training for the NASA astronaut corps. In addition to crew training, these simulations evaluated the new Load Persistence Model, which predicts tire failures, and explored possible load alleviation techniques.

Introduction

NASA's Space Shuttle program was initiated in the early 1970s and features the United States' first reusable space vehicle fleet. As originally conceived, the Space Shuttle program was intended to provide routine, economical access to space and deliver a variety of government and commercial satellites to low-Earth orbit. The goals of the Space Shuttle program have evolved over time and now include servicing the International Space Station (ISS), ferrying both cargo and astronauts to and from the ISS, and developing next-generation reusable space transportation systems.

Since 1980, the Vertical Motion Simulator at NASA Ames Research Center has supported the Space Shuttle program, providing high fidelity, piloted simulations of Space Shuttle landings and rollouts and serving as a critical training facility for the astronaut corps. Indeed, the corps has extremely high confidence in the technical fidelity of the VMS simulations and requires all astronaut pilots to train here. Astronauts experience both typical and off-nominal conditions during simulation, including poor visibility, inclement weather, Auxiliary Power Unit failures, Head-Up Display (HUD) misalignment, nose-wheel steering failure, tire failures, and brake failures. It is far safer for astronauts to train for off-nominal conditions in a ground-based, high-fidelity simulator than to encounter such conditions for the first time in a real flight scenario.



Simulated Space Shuttle with parachute deployed.

In addition to astronaut training, the VMS offers a cost-effective research platform to test enhancements to the Orbiter vehicle. Past research has included modifications to the flight-control system, landing system, and flight rules. For example, flight handling qualities can be tested and evaluated in the VMS before the improvements are actually implemented on the Shuttle. This allows any anomalies to be detected and addressed before they become an expensive, real-life problem. Engineering studies are also conducted in the VMS and have contributed greatly to program safety.



Space Shuttle Endeavour landing at Edwards Air Force Base.

These projects and studies are enhanced by the use of SimLabs' Virtual Laboratory (VLAB) tool. VLAB's collaborative engineering environment enables researchers at Johnson Space Center and Marshall Space Flight Center to interact with VMS experiments in real-time by linking the facilities through a high-speed communications network and specialized software. During Orbiter simulations, remote researchers use VLAB to view live data from the VMS, communicate with the pilot and on-site researchers and engineers, and interact with simulations as they occur. This remote participation capability saves the Shuttle program two very valuable commodities: time and money.

Future Shuttle launches have been postponed until at least 2004. The VMS is capable of playing a critical role in the fleet's Return to Flight by providing enhanced training for the corps, not only in the realm of landing and rollout, but also with "abort on ascent" scenarios. In addition to the standard end-of-mission landing sites (including Kennedy

Space Center, Dryden Air Force Base, and White Sands Missile Range), the VMS currently has 16 Shuttle abort landing sites in its database, covering most abort options for standard Shuttle missions.

The primary focus of this year's Shuttle simulations was astronaut training, including landings at many of the sites in the VMS database. The math model also underwent several modifications, and the cab was physically modified to provide enhanced pilot visibility.



Space Shuttle Endeavour landing at Kennedy Space Center.

Simulation

Training was provided for upcoming mission crews through a series of flight simulations over two separate four-week periods. Various runways, visibility conditions, and wind conditions were simulated, while system failures such as tire failure and HUD misalignment were periodically introduced.

The math model was enhanced in several ways. First, a new Load Persistence Model was incorporated to more accurately predict tire failures. The previous load model was structured around a normal tire load and determined tire failure based on load persistence. Engineers at NASA Langley Research Center created the new model after performing a series of tests with actual Orbiter tires. This new model calculates tire load in accordance with ground speed, side-slip angle, and tire pressure in addition to the normal load; this, in turn, provides a more realistic prediction of tire damage conditions. Using the new model, researchers hope to expand the Orbiter's flight envelope by testing the structural limits of the tires and the pilot's ability to control the vehicle under adverse conditions.

An additional model modification involved the expansion of the SSV visual database. The Elizabeth City Coast Guard Air Station in North Carolina and the Francis S. Gabreski Airport in New York were added as potential East Coast Abort Landing (ECAL) sites. The

math model was further modified to include wind profiles from STS-112 and STS-113. Boeing provided an emulated Backup Flight System, and its use was demonstrated during the second four-week simulation session. Lastly, the Microwave Landing System was verified to ensure its correct implementation and functioning at the VMS.

In addition to the model modifications, the simulator cockpit was upgraded by adding a fourth out-the-window monitor to the right side of the cab. This modification allows the pilot increased peripheral vision and significantly improves situational awareness and head-up flying ability.

Results

During the four-week simulation in January 2003, 35 pilots flew 667 training runs, and 10 mission specialists also received training. Thirty-three pilots flew 603 training runs and 117 engineering runs during a second four-week simulation session which took place during Fall 2003. Four mission specialists also underwent training during the Fall session.

The Load Persistence Engineering Study was completed with six pilots flying 350 data runs. Based on the data collected and pilot ratings, researchers determined that the new Load Persistence Model requires further study. The crew familiarization phase underscored the important role the VMS plays in preparing upcoming crews for Shuttle landings and rollouts and the management of potential off-nominal conditions.

Investigative Team

NASA Johnson Space Center
NASA Ames Research Center
Boeing North American
Lockheed Martin Engineering and Services Corp.
United Space Alliance
Northrop Grumman Information Technology



Astronauts in training at the VMS.

Dallas/Fort Worth International Airport Perimeter Taxiway (DAPT) Demonstration

Principal Investigator: Karen Buondonno, FAA William J. Hughes Technical Center Simulation and Analysis Group

Summary

The DAPT Demonstration resulted from a partnership between Dallas/Fort Worth International Airport (DFW), the Federal Aviation Administration (FAA), and NASA. The Demonstration consisted of a real-time, human-in-the-loop simulation to explore the impact of adding new perimeter taxiways to DFW with regard to safety, efficiency, and cost. This was the first SimLabs experiment that utilized the facilities' newly developed High Level Architecture (HLA) capability.

Introduction

The current runway configuration at DFW requires that aircraft arriving on the main outboard arrival runways cross the main inbound departure runways before arriving at the terminal area. The local controller is responsible for handling all runway crossings before the aircraft can be released to the ground controller. As DFW typically experiences 1,700 runway crossings per day, the local controller's workload is quite heavy. This creates challenges for full utilization of available runways and increases the potential for runway incursions and traffic delays. In an effort to improve airport operations, a perimeter taxiway concept was proposed which includes new taxiways on the east and west sides of the airport.

The main objective of the Demonstration was to provide the airlines, air traffic controllers, and pilots an opportunity to observe and participate in a high-fidelity simulation of the proposed improvements with the goal of gaining user acceptance. A secondary objective entailed the collection and analysis of operational data to derive descriptive statistics for runway crossings, taxi times, and pilot-controller transmissions.

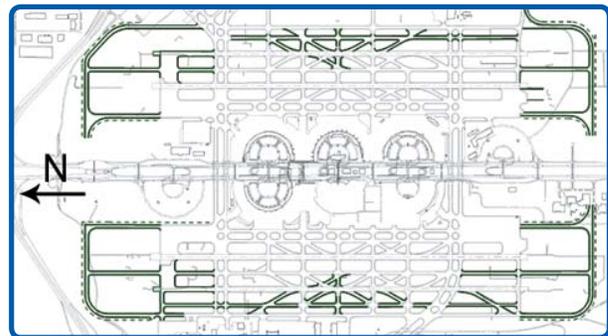
The Demonstration was conducted at Ames Research Center using the facilities at FutureFlight Central (FFC) and the Crew Vehicle Systems Research Facility (CVSRF) to simulate DFW tower and flight deck operations, respectively. The simulators were integrated using HLA bridging technology. This simulation marked the inaugural use of the facilities' newly-developed HLA interface.

Simulation

The FFC tower cab was staffed with five FAA-DFW tower controllers. Full DFW traffic was simulated. For comparison, controllers managed east-side operations under two different taxiway configurations: baseline (the current DFW configuration) and perimeter taxiways (including those proposed with extensions of Runways 17C and 18R and new high-speed exits on 17C and 18R). Traffic scenarios were based on predictions of 2006 traffic volume and fleet mix.

At CVSRF, one staff pilot flew the Boeing 747-400 cockpit simulator, and seven pilot and airline representatives observed from inside the cab over the course of the demonstration. Several scenarios of interest were simulated for the crew while using perimeter taxiways: taxiing on the ground with aircraft passing overhead and flying overhead with aircraft passing below.

Pilots in CVSRF and controllers in FFC evaluated the proposed configuration from their respective vantage points, and tower controllers had the opportunity to refine operational procedures for managing perimeter taxiway traffic.



The proposed DFW perimeter taxiways are shown as darkened lines.

Results

Spanning four days, 13 runs were conducted with the FFC and CVSRF simulators connected in real-time. All objectives of this exercise were met successfully: DFW was able to experience the proposed configuration in a safe, virtual environment and obtain valuable user input before investing in expensive construction. Data collected from the Demonstration showed significant reductions in radio frequency congestion, overall taxi times, and improved efficiency with the perimeter taxiway operation. An informational video of the demonstration and proposed airport improvements was also produced using the visualization capabilities of SimLabs.

Investigative Team

Dallas/Fort Worth International Airport
Federal Aviation Administration
Quantum Services, Inc.
NASA Ames Research Center
Northrop Grumman Information Technology

Third Generation Neural Flight Control System

Principal Investigator: Karen Gundy-Burlet, NASA Ames Research Center

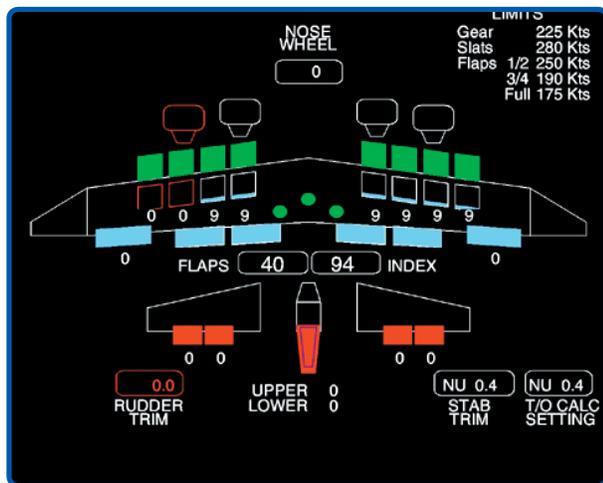
Summary

This project took the Advanced Concepts Flight Simulator's (ACFS) Neural Flight Control System (NFCS) beyond current state-of-the-art to allow alternative control of damaged or malfunctioning aircraft. Simulated flight tests were conducted to document the C-17's characteristics and evaluate its handling qualities in both nominal and failure modes. Researchers were able to develop and validate new algorithms for improved handling qualities.

Introduction

In recent years, a number of commercial airliners have met with accidents because of control system failures. Consequently, the National Transportation Safety Board mandated that NASA develop alternative flight control technologies to provide redundancy should the primary flight control system malfunction or fail. The C-17 cargo transport was chosen as the model system for use in this development.

In 2001, a representative C-17 model was integrated into NASA's ACFS. The Integrated Neural Flight Propulsion Control System (INFPCS) series of simulations was then conducted in 2001 and 2002. The current experiment was a follow-on to the previous studies and upgraded the NFCS algorithms. The aim of this simulation was to develop and test a third-generation (Gen-3) neural flight controller, with the goal of improving handling qualities of the C-17 for a broad range of nominal and failure conditions.



The new SPI is shown above. Red areas (in this image, the shaded boxes at the rear of the aircraft) depict where a failure has occurred.

Simulation

To support this study, several modifications were made to the experimental environment. A newly designed upper Engine Indication and Crew Alerting System (EICAS) display was added that reflects the four-engine configuration and associated monitoring parameters. Additionally, the graphic display of the EICAS' Surface Position Indicator (SPI; see image) was changed to distinguish flight control surfaces in normal or failure modes and provide digital deflection readouts. The Experiment Operator Station was modified to expand the controller and failure mode indicators and enhance monitor and control functions. Other modifications included support for more realistic engine sounds and new aural tones to indicate engine failure.

The simulation model used for this experiment was the wide-body, fly-by-wire C-17 military transport, with the ACFS serving as the test platform. Simulated failure conditions, such as actuator jams at a fixed position and aircraft damage, were introduced; different combinations of 17 separate flight controls (e.g., ailerons, rudders, spoilers, and stabilizer) were employed by the neural system to counteract the failures. NASA and commercial test pilots evaluated handling qualities using Cooper-Harper ratings during select maneuvers and in approach and landing scenarios under a variety of flight conditions.

Researchers recorded the test runs and collected data. Audio responses of the pilots were recorded, as well as video of the out-the-window visual displays and selected aircraft cockpit instrumentation. Time histories for pilot inputs, failure modes, and aircraft dynamics were also collected. Additionally, parameters pertaining to the intelligent flight control system were recorded.

Results

The use of the ACFS C-17 aircraft model enabled researchers to develop, test, and demonstrate new and diverse flight control reallocation techniques within one facility. Researchers were able to develop and validate new algorithms for improved handling qualities, and integration of laboratory neural modeling work into the simulator allowed for flexibility and real-time evaluation of new theories. This effort lays the groundwork for reconfigurable control design applications on a joint Air Force/NASA C-17 research aircraft and future Unpiloted Aerial Vehicle (UAV) and space projects.

Investigative Team

NASA Ames Research Center
QSS Group
Northrop Grumman Information Technology

LAX Phase III: Runway Incursion Studies

Principal Investigator: Andres Garcia, HNTB Corporation

Summary

In June 2003, Los Angeles World Airports (LAWA) returned to NASA FutureFlight Central (FFC) to simulate a center taxiway between Runways 25R and 25L at Los Angeles International Airport (LAX). Aimed at reducing runway incursions, this study was an extension of the previous studies conducted at FFC in February and April 2001. Data indicated that while workload is an issue for the ground control position, the concept of a center taxiway would be viable in reducing runway incursions.

Introduction

LAWA has continued to actively address runway incursions. The most common runway incursions at LAX have occurred when an aircraft arriving on Runway 25L exits at one of the high-speed exits but fails to stop before overshooting the hold-short bars for Runway 25R. Despite many improvements, LAX continued to be challenged by a growing number of runway incursions in 1998 and 1999. Thus, LAX, in cooperation with the Federal Aviation Administration (FAA) and United Airlines, undertook a simulation study at NASA Ames' FutureFlight Central in 2001, *The Los Angeles International Airport Runway Incursion Studies: Baseline and Alternatives Simulations*.

LAWA returned to FFC in June 2003 to simulate a center taxiway between Runways 25R and 25L (an option the airport is studying as part of its Master Plan for modernization). This concept will direct aircraft onto a parallel center taxiway, thus eliminating the "straight shot" (per current operations) to Runway 25R and providing controllers with more options for holding and crossing arriving aircraft—especially during peak traffic periods.

Simulation

In order to meet FAA requirements, FFC's virtual model of LAX shifted Runway 25L fifty feet to the south, providing the necessary space for the center taxiway between runways. FutureFlight staff modified the existing 3-D visual database of LAX to include a center taxiway with connecting taxiways between runways 25L and 25R (see image). The traffic scenarios replicated those

simulated in 2001, which reflected pre-9/11/2001 traffic conditions. Both the north and south sides of LAX were simulated with an aircraft mix representative of LAX in the summer of 2000. Traffic was run under both full visibility and reduced visibility conditions.

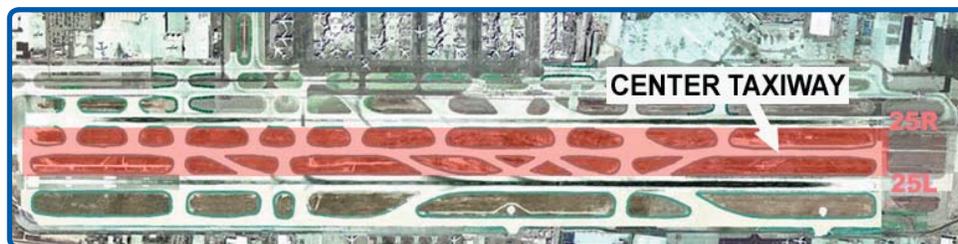
Using the proposed center taxiway configuration, four controllers from the LAX tower managed traffic with rates ranging from 145 to 161 operations per hour. The simulation spanned three days, during which twelve 45-minute runs were completed. To more fully evaluate workload issues, the last three runs were conducted with more restrictive operational rules developed specifically for the simulation, which increased controller workload on the south side of the airport. HNTB Corporation, the National Air Traffic Controllers Association, the FAA, and FFC personnel collaborated to define the operational rules by which traffic was managed on the south-side airfield.

Results

After each run, controllers evaluated various aspects of the simulation including safety, complexity, and manageability. The South Local controller rated center taxiway operations as somewhat more efficient, safe, and manageable when compared to pre-9/11 operations without a center taxiway. Objective measurements (e.g., transmissions per hour and average arrival taxi time) indicated, however, that the overall efficiency of the airport was not significantly impacted. Overall conclusions indicated that, while workload is an issue for the ground control position, the concept of a center taxiway would be a viable means of reducing runway incursions at LAX, thus increasing overall safety.

Investigative Team

NASA Ames Research Center
HNTB Corporation
Los Angeles World Airports
Northrop Grumman Information Technology
Federal Aviation Administration



Modified south-side LAX layout, showing center taxiway.

Pilot/Controller-in-the-Loop Study of Low-Noise Arrival Procedures

Principal Investigators: Kevin Elmer and Joseph Wat, The Boeing Company

Summary

NASA's Crew Vehicle System Research Facility (CVSRF) conducted a study of low-noise arrival procedures in conjunction with the Boeing Company, the Federal Aviation Administration (FAA), and Massachusetts Institute of Technology (MIT). Researchers studied the impact of Noise Abatement Procedures (NAPs)—with emphasis on Continuous Descent Approach (CDA)—on controller workload. Experimental data will be used to design and improve CDA controller tools and procedures and will provide significant advancement to NASA's Aviation Systems Capacity Program.

Introduction

Aircraft noise affects not only airport personnel and travelers, but the surrounding communities, as well. NASA is actively involved in reducing airport and community noise by exploring new technologies to reduce engine system noise and airframe system noise, and by developing procedures to minimize ambient noise. The collaborators of this study seek to further the development of Noise Abatement Procedures for numerous airports to minimize perceived noise impact to the surrounding communities.

In 2001, NASA partnered with the Boeing Company, the FAA, and MIT to study low-noise arrival procedures. A recent experiment, conducted at NASA's CVSRF, investigated solutions in support of NASA's aim to "confine objectionable noise within airport boundaries." In the current experiment, researchers studied the impact of NAPs—with specific emphasis on CDAs—on air traffic controller workload. Data collected will be used to create a new database for noise, emissions, aircraft performance, and inter-aircraft spacing for CDA arrival procedures during final approach in the Terminal Radar Approach Control area. This database, in turn, will be used to design improved CDA controller tools and procedures, which will be of great value in achieving the goal of noise abatement.

Simulation

Researchers simulated operations at Louisville-Standiford Field in Kentucky during the last block of aircraft approaches from the West Coast using a "contra-flow" south mode of operations, which is employed when weather conditions prevent north flow arrivals. CVSRF's B747-400 flight simulator was operated in conjunction with the facility's Air Traffic Control (ATC) simulator. An addition to this experiment was the PCPlane, a simulation program provided by NASA Langley Research Center to emulate a Boeing 757-200. The 747 and 757 flew CDA procedures, while the remaining simulated arrival aircraft

followed normal step-down arrival procedures per ATC instructions.

Four controller test subjects were assigned to each test and were delegated side tasks in addition to their responsibility for maintaining aircraft separation. Researchers recorded performance data from the B747-400 simulator as well as trajectory information for the other-target-generated air traffic during each flight. Data was also gathered from PCPlane, and aircraft performance was measured by comparing prescribed aircraft parameters to the actual parameters recorded during the simulation. The simulators generated files with time and position information for the 747 and 757 (plus the five closest aircraft) based on the range bearing data calculated for the Traffic Alert and Collision Avoidance System (TCAS).

ATC performance was measured subjectively in terms of perception, cognition, motor workload, and situational awareness and was indicated by incremental time-delays in controllers' responses to random external communications and control actions.

Results

The goals of the simulation were successfully met. Data gathered from this study will be analyzed to evaluate ATC performance. Subjective opinions (obtained by questionnaire) regarding ATC execution of tasks will also contribute to the data collected. The difference between the actual and target separation at touchdown will also be used as a measure of controller performance.

Investigative Team

The Boeing Company
NASA Ames Research Center
Northrop Grumman Information Technology



CVSRF's ATC simulator operated in conjunction with the B747-400 flight simulator during this study.

Comanche Helmet-Mounted Display Symbology Simulation

Principal Investigator: Jay Shively, NASA Ames Research Center

Summary

This simulation compared pilot performance using several Helmet-Mounted Display (HMD) symbology sets (Comanche Contact Analog, MIL STD-1295, and hybrids of the two). The overall effectiveness of the different heading tapes and altitude symbols was evaluated. Results will be used by the Aviation and Missile Research and Development Engineering Center (AMRDEC) to support Comanche airworthiness evaluations.

Introduction

The Comanche RAH-66 is an elite rotorcraft model designed to be the next-generation scout and attack helicopter for the U.S. Army, and it is the cornerstone of the Army's Force XXI Aviation Modernization Plan. This rotorcraft incorporates the latest advancements in technology including a binocular HMD known as the Helmet Integrated Display Sighting System (HIDSS). The HIDSS serves as the pilot's primary flight display and uses newly developed symbology in which symbols appear to overlay the real-world objects they represent. Use of this system will allow pilots to fly the vehicle in all weather and lighting conditions.

The Vertical Motion Simulator (VMS) is uniquely suited for rotorcraft simulations because of its large amplitude motion system and its 60 feet of vertical travel displacement. Because of this high fidelity, the Army chose the VMS as the site for its Comanche HMD research.

This test was the second in a series of symbology evaluations conducted at the VMS. Initial tests by Army pilots with the Comanche symbology revealed several issues regarding the new symbology presentation style of the HIDSS. Current simulations addressed these concerns by comparing pilot performance using each of the symbology sets under identical flight scenarios.

Simulation

The effectiveness of the HMD symbology sets—Comanche Contact Analog, MIL STD-1295, and several hybrids of the two—was evaluated using three types of tasks: handling qualities, situational awareness, and mission-oriented. Emphasis was placed on quantifying the performance, workload, and overall effectiveness of the heading tape and altitude symbols.

To prepare for the simulation, SimLabs' engineers integrated and evaluated the RAH-66 simulation model previously developed at NASA Ames Research Center. The engineers then developed software to support the various flight tasks, including: (1) sequencing the appearance of ground vehicles along the flight routes and calculating

the azimuth from the helicopter's present position; (2) detecting and counting ground strikes and collisions with objects on the ground; and (3) performing data collection and statistical calculations, and providing data displays. In addition, they developed real-time graphics for the three symbology sets and the lab data displays.

To conduct the evaluation, each test pilot flew the simulated Comanche wearing an HMD equipped with a sensor for tracking head movement. The pilot used the Comanche symbology set to fly several runs and perform assigned flight tasks. The helicopter's automatic flight control system and forward-looking infrared visual system were used for all runs. The pilot then repeated the same runs using each of the other symbology sets.



An example of the out-the-window database used during this simulation.

Results

Six pilots used the HMD with each of the symbology sets to fly 609 data runs of the simulated Comanche helicopter. The experiment objectives were successfully accomplished. Data analysis is underway, and final results will be used by the AMRDEC to support Comanche airworthiness evaluations.

Investigative Team

Turpin Technologies
San Jose State University
NASA Ames Research Center
Northrop Grumman Information Technology

Principal Investigator: Dr. Dawn Elliott, NASA Kennedy Space Center

Summary

This simulation successfully demonstrated the feasibility of virtual training for Kennedy Space Center (KSC) Space Shuttle landing operations personnel. Four different situations were simulated, ranging from routine operations to emergency situations.

Introduction

NASA's Space Shuttle Orbiters are valuable national assets. Consequently, operational procedures and processes have been developed to ensure a safe launch and return to Earth for each Orbiter mission. Orbiter landings at KSC's Shuttle Landing Facility have occurred, on average, six to eight times per year. With landings of this frequency, it can be difficult to train and maintain crews in standard operational procedures, and to augment and develop new operational and emergency procedures. Virtual training, however, enables tower controllers and support personnel to practice and refine procedures by providing them with simulated Shuttle operations. Additionally, stopping and/or replaying elements in a simulation gives crews the opportunity to perfect their responses in different situations.



View of the medical scenario emergency vehicles to aid the Shuttle crew. The gray rescue vans are positioned to evacuate injured personnel to the triage decontamination site.

In 2002, personnel from KSC used the virtual environment at NASA Ames FutureFlight Central (FFC) to validate their choice of a new tower location, tower height, and interior cab arrangement. The 3-D database developed for that simulation was augmented and subsequently used in the two-day KSC Shuttle Landing Facility Training Demonstration in 2003. The Demonstration developed and showcased a virtual training environment for landing facility personnel who must cope with a variety of situations.

In exploring virtual training environments, KSC is working to ensure the safety of Orbiter landings and enhance personnel training.

Simulation

During the Demonstration, the FFC tower was staffed with several controllers from FFC, Langley Research Center, and the Moffett Federal Airfield Tower. Convoy and medical personnel were in attendance as observers and participants, and four typical operations were simulated: day-to-day operations, convoy vehicle deployment, coordination of medical emergency response upon Orbiter landing, and coordination of security breach response.

The day-to-day scenario represented routine Shuttle Landing Facility operations. It included the return of an Orbiter riding "piggyback" on top of a Boeing 747 carrier aircraft, as well as various air traffic operations and situations. The convoy scenario simulated a standard set of post-flight safety inspections, deploying many vehicles to help the crew deplane, unload experiment apparatus, and secure the Orbiter. As part of its preparations for the convoy simulation, FFC included additional air and ground vehicle models in its database, bringing the number of convoy vehicles deployed to 42. In the medical emergency scenario, a fire emergency was simulated. Fourteen vehicles were dispatched, including fire trucks and other emergency vehicles, and a triage site was set up on the runway. An attending medical doctor directed rescue and helicopter support for treating and evacuating the Orbiter flight crew. Lastly, during the security scenario, controllers rehearsed procedures to be implemented when an aircraft inadvertently enters the restricted airspace around KSC during Shuttle launch or landing.

Results

FFC successfully simulated the four scenarios, thus demonstrating the feasibility of using a high-fidelity virtual environment in personnel training and skills maintenance. Principal Investigator Dr. Dawn Elliott stated, "In this phase, we explored an alternate way of training. Actual opportunities for training with a full complement of vehicles are limited, but a virtual environment is available whenever it's needed." Further tests and results are pending.

Investigative Team

NASA Kennedy Space Center
NASA Ames Research Center
Northrop Grumman Information Technology

Virtual Flight Rapid Integration Test Environment V

Principal Investigators: Julie Mikula, NASA Ames Research Center; and John Bunnell, Northrop Grumman Information Technology

Summary

Virtual Flight-Rapid Integration Test Environment (VF-RITE) is a multiphase project that uses Computational Fluid Dynamics-derived aerodynamic data in the development and evaluation of air vehicle designs with real-time, piloted flight simulation. VF-RITE V marked the successful integration of NASA's Information Power Grid (IPG) and the VF-RITE infrastructure, providing enhanced flexibility in the allocation of computational resources for calculation of aerodynamic data.

Introduction

VF-RITE uses aerodynamic data [developed with Computational Fluid Dynamics (CFD)] and other IT tools to develop and evaluate air vehicle designs in real-time, piloted flight simulations. This approach allows designs to be tested by pilots in a simulation environment and then modified within days or even hours of pilot feedback. The approach is computationally intense, and NASA's Information Power Grid (IPG) offers a unique solution to this computing challenge. Specifically, the IPG is a high-performance network that integrates geographically distributed computers, enabling researchers to run multiple concurrent jobs on different machines. This set-up offers increased flexibility in the allocation of resources used in the calculation of data.

VF-RITE is a multiphase project. To date, all phases of the project have been accomplished at NASA Ames using the Vertical Motion Simulator (VMS), but the process itself is transferable to any facility with the necessary infrastructure. The first phase of the program united separate aerodynamic disciplines to establish the infrastructure for rapid integration of CFD data into flight simulation. The next phase demonstrated a redesign of the Space Shuttle's nose, and back-to-back comparisons of the vehicle were made using different geometries. VF-RITE III applied the IT tools developed during the first two phases of the program to the preliminary design of a Crew Transfer Vehicle (CTV). The fourth phase studied the latest CTV concept vehicle, the CTV-8 (Figure 1), with the goal of improving the vehicle's flight controls, Head-Up Display, and the VF-RITE process itself.

The objective of this latest phase, VF-RITE V, was to use CFD codes and other IT tools to integrate the IPG and the VF-RITE infrastructure, thereby enhancing the flexibility of resource utilization. Subjective and objective flight simulation data will allow the design team to apply "return knowledge" from the simulation to improve vehicle design.

Simulation

Using the IPG, aerodynamic data from VF-RITE IV was recalculated for the CTV-8 and for a tail-less version of the CTV to demonstrate how new concepts and configurations could be rapidly calculated and tested. OverflowD, a CFD code based on the Navier-Stokes viscous flow equations, was used to calculate the basic forces and moments of the vehicles; CART3D, a CFD code based on the Euler formulation of the non-viscous flow equations, was used to calculate forces and moments due to control deflections.

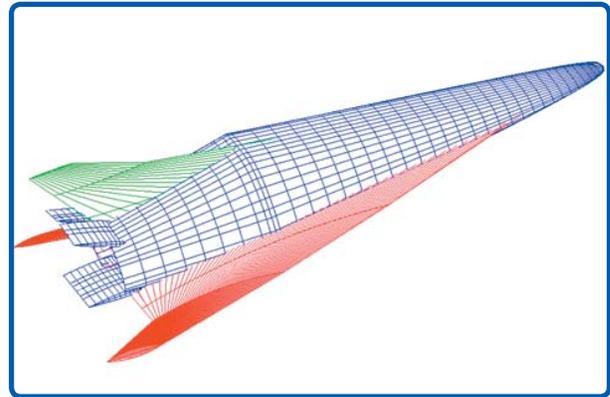


Figure 1. Wire-frame diagram of the CTV-8.

Upon completion of the development process, the CFD data was downloaded to the VMS, and the CTV's stability, control, and handling qualities were demonstrated in a real-time simulation with a pilot in the loop. Subject pilots flew three approach and landing tasks: a straight-in approach with no wind; a lateral offset approach with no wind; and a straight-in, gusty crosswind scenario. The process was then immediately repeated with the tail-less configuration, demonstrating how quickly and easily aerodynamic data for a new configuration could be calculated and tested in the simulator.

Results

The IPG and the VF-RITE infrastructure were successfully integrated, resulting in improved flexibility for the utilization of computational resources to perform the necessary CFD computations for flight simulations. The real-time simulations demonstrated the ease with which data can be recalculated after receiving pilot feedback from evaluating the original design configuration.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology
Advanced Management Technology, Inc.

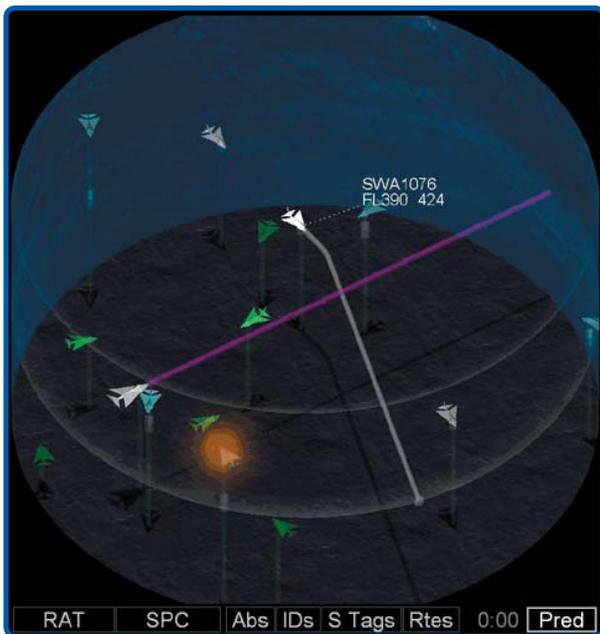
Principal Investigator: Everett Palmer, NASA Ames Research Center

Summary

The Distributed Air-Ground (DAG) system examines human factors issues related to the integration of new air transportation technologies. Improvements are being made to facilitate remote simulator connectivity during experiments and to enhance navigation performance. In an upcoming demonstration that builds upon previous work, the Advanced Concepts Flight Simulator (ACFS) will be linked to the Airspace Operations Laboratory (AOL) to demonstrate DAG concepts in real-time.

Introduction

DAG research is a part of the Advanced Air Transportation Technologies (AATT) Program, which explores various aspects of the National Airspace System. This study is examining human factors issues related to the interactions between the airborne flight crew and ground-based air traffic controllers. In previous demonstrations, SimLabs' development effort centered primarily on the ACFS, which plays a critical role in DAG research.



3-D CDTI display during a traffic alert.

The Cockpit Display of Traffic Information (CDTI; see image), a key element of DAG research, was previously developed by the DAG team. It consists of display graphics and includes both self-separation and conflict detection

logic. The CDTI was integrated into the ACFS via the Aeronautical Datalink and Radar System (ADRS). The ADRS, in turn, serves as a gateway to simulated air traffic and the Center and Terminal Radar Approach Control (TRACON) environments remotely located in the AOL. By linking the ACFS, AOL, and CDTI Labs at Ames with the CDTI Lab at Langley Research Center, pilots and controllers were able to use DAG tools in real-time simulation scenarios. Researchers will continue to integrate new versions of CDTI and ADRS as they evolve. In addition, improvements are being made to the flight management system of the ACFS for the purpose of accommodating new datalink messages and enhancing vertical/lateral navigation performance.

As part of the DAG research effort, a demonstration and data collection phase, building on last year's work, will begin in the ACFS in October 2003. The aim is to integrate and demonstrate incremental improvements in the DAG system and validate the integration of NASA's remote simulation facilities. Prior to the demonstration, a final "dress rehearsal" will be conducted in early October.

Simulation

Several test sessions have already been run, culminating in an "end-to-end" test in mid-August that validated the simulation setup and the voice-communications systems. For the upcoming demonstration, the ACFS will be linked to the AOL. Various crews will fly the ACFS during the scenarios using DAG tools. The CDTI airborne logic will be used in the Center environment to resolve traffic conflicts using self-separation logic. Self-spacing speed algorithms developed by NASA Langley will be available in the approach phase of flight to examine increased traffic flow. The Crew Activity Tracking System has been integrated into the experimental setup and will be used to collect data during the demonstration. Data will also be collected with the ACFS's built-in data collection system.

Results

As of this writing, the data collection phases of this simulation were pending. Results of this study will be published in an upcoming Annual Report.

Investigative Team

NASA Ames Research Center
NASA Langley Research Center
Steglinski Engineering
San Jose State University
Northrop Grumman Information Technology

Featured Project

Virtual Airspace Simulation Technology-Real-Time

FEATURED
PROJECT

Principal Investigators: Scott Malsom, NASA Ames Research Center; and Ronald Lehmer, Northrop Grumman Information Technology

Summary

The Virtual Airspace Modeling Systems (VAMS) Project has been established by NASA in partnership with the Federal Aviation Administration (FAA), academia, and industry to develop air traffic management technologies that will increase the capacity of the National Airspace System (NAS) while providing a safer and more efficient operational environment. VAMS established the Virtual Airspace Simulation Technology-Real-Time (VAST-RT) Project at Ames Research Center to lead the real-time, human-in-the-loop portion of this initiative by developing new tools for creating and executing gate-to-gate simulations and by demonstrating these capabilities in integrated simulations using multiple existing simulation facilities. The VAST-RT simulation environment provides revolutionary new capabilities to evaluate human factors and detailed human interactions aspects of air traffic management and air traffic control concepts at both the system and local levels of the NAS.

Introduction

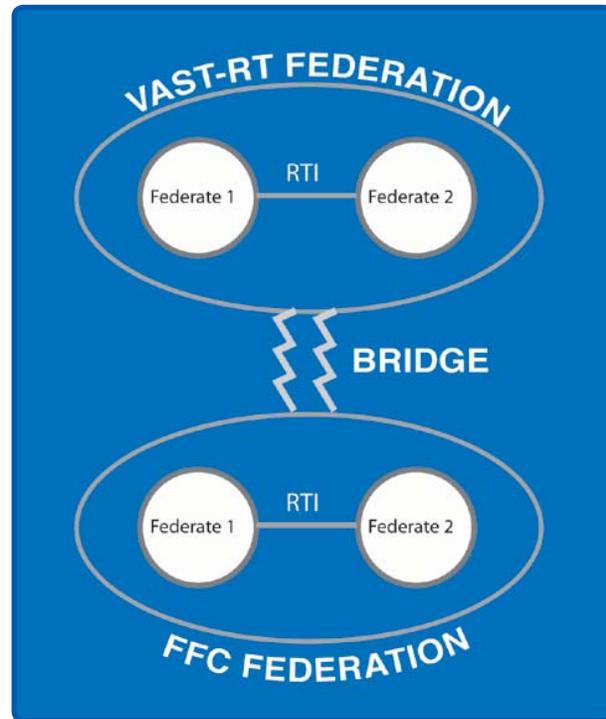
As the demand for air travel and shipping continues to increase, air transportation is growing at an unprecedented rate. This increased volume is likely to cause overcrowding in the air as well as on the ground, given our current air transportation system. Consequently, there is a pressing need to increase the capacity of the NAS and develop a new and more efficient operational environment.

To address these issues, NASA has formed partnerships with the FAA, academia, and industry to develop new Air Traffic Management (ATM) technologies that will increase the capacity of NAS while providing a safer and more efficient air transportation system. A five-year Project, VAMS, was initiated in 2000. The Virtual Airspace Simulation Technologies (VAST) Project is an essential sub-element of VAMS and is responsible for the development and delivery of the simulation tools necessary for the other elements in the VAMS Project to evaluate the effectiveness of new ATM concepts.

The VAST Project comprises two entities: Airspace Concept Evaluation Systems (ACES), a non-real-time modeling and simulation capability that focuses on assessing and validating non-real-time/fast-time models of operational concepts; and VAST-RT, which consists of gate-to-gate, real-time, human-in-the-loop simulation capabilities to assess human interactions with airspace operating concepts and technologies. ACES and VAST-RT provide different types of functionality for evaluating these concepts. ACES offers superior capability to assess system-wide concepts with low fidelity models that run in fast-time (as required for Monte Carlo analyses), while

VAST-RT excels at performing a more detailed evaluation in real-time within specific areas in the NAS using medium- to high-fidelity models and human participants.

The underlying VAST-RT architecture relies on High Level Architecture (HLA), a Department of Defense software suite that is used to connect applications and facilities in a real-time simulation. Typically, HLA works by combining disparate simulation systems (“federates”) into a larger, common “federation,” where information is exchanged in real-time between federates using Run-Time Infrastructure (RTI) software. In the VAST-RT architecture, the HLA communications infrastructure is integrated with existing simulators using existing external interfaces where possible to minimize the cost and impact of connecting the simulators to the HLA federation.



HLA works by combining disparate federates into a federation. Information is exchanged in real-time between the federates using RTI software.

The VAST-RT plan includes a series of regularly scheduled releases and simulations that have been established as Project milestones to demonstrate capability prior to the verification simulations that constitute VAMS Project milestones. There will be a total of six simulations and demonstrations, with each installment building

Virtual Airspace Simulation Technology-Real-Time

FEATURED
PROJECT

on the results of the previous ones. The simulations are being conducted at multiple NASA facilities, including FutureFlight Central (FFC), the Crew Vehicle System Research Facility (CVSRF), and the Vertical Motion Simulator (VMS). Four interim tests (IT #1-4) have been completed to date. The fifth and sixth interim tests are scheduled to occur in FY 2004.

Simulation

Performance of the VAST-RT environment with interconnected simulators was measured quantitatively and qualitatively during the tests described below. Quantitative assessments were made of system and network loading, including loading systems with unrealistic air traffic loads. Qualitative measurements of out-the-window, flight-deck, and controller displays were also made, along with evaluations of operational procedures to run such distributed simulations.

IT #1: This first test in the series successfully demonstrated the basic VAST-RT HLA communications architecture for a distributed simulation (i.e., between multiple simulators). CVSRF was selected for this demonstration because it contains several simulation systems which reside in one building that have been integrated in the past. Three simulators in CVSRF—the Boeing 747-400, the Advanced Concepts Flight Simulator (ACFS), and the Air Traffic Control (ATC) Laboratory—were modified to act as independent HLA federates within a VAST-RT HLA federation.

IT #2: The second test was designed to demonstrate and validate VAST-RT HLA bridging technology between the CVSRF Boeing 747-400 simulator and FFC's tower simulator. HLA bridging technology allowed two HLA federations to successfully share data, spanning differences in software version and data modeling that would otherwise make integration of the separate HLA federates impossible. Significant progress was also made on the development of procedures to align visual databases in both the tower and cockpit visual displays.

IT #3: The third test consisted of several new software components and simulation scenarios that improved the distributed simulation capability of VAST-RT. First, the VMS was integrated into the VAST-RT federation. Then, the Collaborative Development Environment (CDE) Server, a real-time data server for researcher applications, was successfully demonstrated for the first time in the Project. VAST-RT also expanded its data collection and voice communications capabilities for this test.

During this phase, the HLA communications infrastructure was repackaged into a standard set of applications

known as the VAST-RT HLA Communications Toolbox. A cornerstone of the entire VAST-RT system architecture, the HLA Communications Toolbox was integrated as the HLA interface for the simulators in the VMS and CVSRF. The VAST-RT CDE Server and the data collection system also utilized the standard interface of the HLA Communications Toolbox to rapidly integrate these features into VAST-RT.

IT #4: The most recent interim test was designed to evaluate the VAST-RT Airspace Target Generator (ATG). San Francisco International Airport (SFO) and Los Angeles International Airport (LAX) were used as a city pair to demonstrate change-of-ownership between simulations at adjacent Air Traffic Control centers. The goals of this test included further demonstration of the VAST-RT data logging functionality and the implementation of an enhanced HLA Federation Object Model containing flight plan and other ATC information.



View from the FFC control tower during IT #2. Because of HLA "Bridging Technology," multiple simulators can participate in the same scenario in real-time.

Results

Sufficient data was collected to demonstrate, verify, and validate the operation of the new VAST-RT HLA communications scheme. Acceptance Test Procedures were successfully completed, and all Project milestones were met. Preparations for the next interim test (IT #5) are well underway.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology

Acronyms

A

AATT.....	Advanced Air Transportation Technologies
ACES.....	Airspace Concepts Evaluation Systems
ACFS.....	Advanced Concepts Flight Simulator
ADRS.....	Aeronautical Datalink and Radar System
AMRDEC.....	Aviation and Missile Research and Development Engineering Center
AOL.....	Airspace Operations Laboratory
ATC.....	Air Traffic Control
ATG.....	Airspace Target Generator
ATM.....	Air Traffic Management

B

B747.....	Boeing 747-400
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C

CDA.....	Continuous Descent Approach
CDE.....	Collaborative Development Environment
CDTI.....	Cockpit Display of Traffic Information
CFD.....	Computational Fluid Dynamics
CTV.....	Crew Transfer Vehicle
CVSRF.....	Crew Vehicle Systems Research Facility

D

DAG.....	Distributed Air-Ground
DAPT.....	Dallas/Fort Worth Perimeter Taxiway
DFW.....	Dallas/Fort Worth International Airport

E

ECAL.....	East Coast Abort Landing
EICAS.....	Engine Indication and Crew Alerting System
ESTOL.....	Extreme Short Take-Off and Landing

F

FAA.....	Federal Aviation Administration
FFC.....	FutureFlight Central
FMS.....	Flight Management System
FOM.....	Federation Object Model
FY.....	Fiscal Year

G

GUI.....	Graphical User Interface
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H

HDD.....	Head-Down Display
HIDSS.....	Helmet Integrated Display Sighting System
HLA.....	High Level Architecture
HMD.....	Helmet-Mounted Display
HUD.....	Head-Up Display

I

INFPCS.....	Integrated Neural Flight and Propulsion Control System
IPG.....	Information Power Grid
ISS.....	International Space Station
IT.....	Information Technology
IVME.....	Integrated Vehicle Modeling Environment

K

KSC.....	Kennedy Space Center
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Continued next page...

Acronyms

L

LAWA..... Los Angeles World Airports
LAX..... Los Angeles International Airport

M

MIT..... Massachusetts Institute of Technology
MSFC..... Marshall Space Flight Center

N

NAP..... Noise Abatement Procedure
NAS..... National Airspace System
NASA..... National Aeronautics and Space Administration
NATCA..... National Air Traffic Controllers Association
NFCS..... Neural Flight Control System

P

PACI..... Partnership for Advanced Computational Infrastructure
PAS..... Pseudo-Aircraft System
PC..... Personal Computer

Q

QAT..... Quiet Aircraft Technology

R

RITE..... Rapid Integration Test Environment
RTI..... Run-Time Infrastructure

S

SFO..... San Francisco International Airport
SGI..... Silicon Graphics, Incorporated
SimLabs..... Simulation Laboratories
SNI..... Simultaneous Non-Interfering
SPI..... Surface Position Indicator
SSV..... Space Shuttle Vehicle
STS..... Space Transportation System

T

TCAS..... Traffic Alert and Collision Avoidance System
TRACON..... Terminal Radar Approach Control

U

UAV..... Unpiloted Aerial Vehicle

V

VAMS..... Virtual Airspace Modeling Systems
VAST..... Virtual Airspace Simulation Technology
VAST-RT..... Virtual Airspace Simulation Technology-Real-Time
VF-RITE..... Virtual Flight-Rapid Integration Test Environment
VLAB..... Virtual Laboratory
VMS..... Vertical Motion Simulator



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